Journal of the Minnesota Academy of Science

Volume 43 | Number 1 Article 6

1977

Successive Month Temperature Relationships for Twin Cities, 1820-1974

Charles J. Fisk
International Business Machines Corporation, Rochester, Minnesota

Successive Month Temperature Relationships for Twin Cities, 1820 - 1974

CHARLES J. FISK*

ABSTRACT - Using a five category classification scheme of mean monthly temperatures, the long-term (1820-1974) relationships between Minneapolis-St. Paul successive months' temperatures were analyzed. Results show predominance of two-month persistence over two-month breaks in classification. Strong above normal and below normal persistence tendencies are revealed, particularly in summer and early fall sequences. In contrast, two-month breaks in classification appear in spring and fall sequences. This emphasizes the uneven progression of warming (cooling) that occassionally occurs between winter (summer) and summer (winter). Overall, strongest month-to-month association was for August-September, weakest for April-May.

Successive months' temperature relationships have been of twofold importance in meteorology and climatology. Research findings have 1) aided in long-range temperature forecasting and 2) made possible a better understanding of month-to-month changes in upper-air circulation patterns, surface temperature and upper-air circulation being closely related. Namais (1952), in a nineteen-year study on 200 United States stations, discovered overall, strongest temperature persistence between July and August, weakest between April and May, and October and November. Dickson (1966), in an eighty-year study on month-to-month mean state temperatures, found regional contrasts in persistence, some state groupings being considerably more likely to experience it than others.

This study, utilizing a five-category scheme of mean monthly temperatures, analyzed for Minneapolis-St. Paul, Minnesota the 1820-1974 incidence of two-month persistence ("regimes") and breaks ("shifts") in mean temperature classifications. Regimes were by definition two-month sequences with identical classifications. Shifts were sequences with the classifications differing by more than one category. Given the 155-year sample size, results hopefully would reflect the inherent character of Minneapolis- St. Paul adjacent months' temperature relationships significantly.

The data were combined records of Fort Snelling (1820-1858), St. Paul (1858-1890), and Minneapolis (1891-1974) monthly mean temperatures. These constitute one of the oldest such histories for a single locality in the United States. Data for the 1873-1974 period were from United States Weather Bureau observations at St. Paul and Minneapolis. Those prior to 1873 were from records kept by Army surgeons at Fort Snelling and civilian observers in St. Paul.

As often occurs in lengthy single-station temperature analyses, the consolidated Minneapolis-St. Paul data were not entirely homogeneous. Differences in observational procedures, data quality, site, and environment were all reflected to some degree in the reported mean temperatures. Nor were averaging methods consistent over the long observational history.

Monthly means for the pre-weather bureau era (1820-1872) were based on averages of several selected hours or times, while the weather bureau means were derived from monthly averages of 24-hour maxima and minima. Also, some of the pre-weather bureau data showed evidence of severe sun contamination, mostly the result of poor positioning of instruments for morning readings. For example, most monthly 7 a.m. temperatures at Fort Snelling in summer (June-August) were higher than the average 2 p.m. readings; normally, Minneapolis-St. Paul 7 a.m. temperatures in June-August average 10° F to 15° F lower than the 2 p.m. temperatures. This overexposure to morning sun at Fort Snelling produced many reported monthly means that were overstated by several degrees.

A two-step procedure was followed to eliminate sun contamination from the affected 1820-1872 data and to adjust the data to the weather bureau's averaging method. First, to remove sun contamination, each 1820-1872 monthly mean temperature (except May-December 1858) was re-expressed as its average 9 p.m. temperature, after sunset on all days of the year at the 45° latitude of Minneapolis-St. Paul.[1] Fortunately, 9 p.m. data were available for all the pre-weather bureau era months except May-December 1858. Second, to adjust the 9 p.m. data to the weather bureau's averaging method, monthly correction factors (ranging from -1.1° F to +1.1° F) were applied, based on average differences, by month, between 1937-74 Minneapolis monthly average 9 p.m. vs. 1937-74 monthly average mean temperatures.

Table 1.

Minneapolis-St. Paul Mean Temperatures and Standard Deviations, 1820-1974 (excluding May-December 1858)

Month	Mean	Std. Dev.
January	— 12.2 F	6.67
February	16.2	6.41
March	28.7	6.04
April	45.0	4.39
May	57.4	3.76
June	67.1	3.25
July	72.2	2.99
August	69.6	2.99
September	60.0	3.76
October	48.2	4.40
November	31.9	4.51
December	17.9	6.22

*CHARLES J. FISK received a B.S. degree in Business Administration with a minor in Geography from the University of Minnesota in 1968, and a Master's degree in Business Administration with a minor in Statistics from Mankato State University in 1973. He is currently employed with International Business Machines Corporation in Rochester, Minnesota.

Other data incontinuities, not directly isolatable, resulted from changes in instrumentation, inter-station moves, instrument relocations and, perhaps most significantly, the localized warming of the Twin Cities associated with urbanization and industrialization.

Given these inhomogeneities, the approach of analyzing category frequencies rather than reported mean temperatures was very useful, classification of the means obscuring the influence of many discrepancies.

Categorization of the Monthly Means

All the monthly means for the period January 1820 to January 1975 were classified according to a five-category scheme: "much below normal," "below normal," "near normal," "above normal," and "much above normal," (Table 2) based on 1820-1974 (excluding May-December 1858) average mean temperatures and standard deviations for each month (Table 1). The scheme was constructed so that ideally, much below normal and much above normal means would each occur one-eighth of the time, and below normal, near normal, and above normal means each one-fourth of the time.

Three types of two-month regimes ("cold", "near normal", and "warm") and two types of two-month shifts ("cold" and "warm") were analyzed, utilizing the classified monthly means.

Cold (warm) regimes were identified if both months in a sequence were either much below normal (much above normal) or below (above) normal; near normal regimes when both months' classifications were near normal. Cold (warm) shifts were identified if the succeeding months' classification was two or more (maximum: four) categories lower (higher) than the initial month's. This analytical format was not all-inclusive; successive months with "above normal"-"near normal", "below normal"-"near normal", "near normal"-"above normal", and "near normal-"below normal" classifications were by definition neither regimes nor shifts, and therefore not included.

Regime and shift incidence was measured by expressing observed incidence as a percentage of maximum possible incidence (i.e., empirical probabilities of occurrence). To illustrate regime incidence computation, 57 Januarys were classified as "cold" (much below normal and below normal categories combined) with 30 of these Januarys being followed by cold Februarys; this made January-February cold regime incidence 30/57 or 52.6 percent. To illustrate shift incidence computation, 97 Januarys were classified as much below normal, below normal, and near normal, with 19 of these Januarys being followed by Februarys that were two or more categories higher; January-February warm shift incidence was thus 19/97 or 19.6 percent. Expected incidence of warm and cold regimes each was 37.5 percent, near normal regimes 25.0 percent, and warm and cold shifts each 32.5 percent.

Table 2 Incidence by sequence of Cold and Warm Shifts 1820-1974

Sequence	Cold Shift Incidence (Original Proportions in Parentheses)	Warm Shift Incidence
January-February	.276 (19/98)	.196 (19/97)
February-March	.232 (23/99)	240 (24/100)
March-April	.250 (24/96)	.242 (24/99)
April-May	.311 (32/103)	.287 (27/94)
May-June	.270 (24/89)	.253 (24/95)
June-July	.206 (20/97	.224 (22/98)
July-August	.198 (19/96)	.194 (18/93)
August-September	.163 (16/98)	.155 (15/97)
September-October	.245 (23/94)	.224 (22/98)
October-November	.297 (27/91)	.247 (24/97)
November-December	.269 (25/93)	.283 (28/99)
December-January	.255 (25/98)	.278 (27/97)

Table 3. Incidence of Cold, Warm and Near Normal Two-Month Temperature Persistence, with associated t-values, by sequence, Minneapolis–St. Paul, 1820-1974

Sequence	Cold Persistence	Warm Persistence	Near Normal Persistence	Incidence	t-value	Incidence	Incidence		t-value
Jan.-Feb.	.526	(30/57)	+2.35	.500	(29/58)	+1.97	.325	(13/40)	+1.10
Feb.-Mar.	.464	(26/56)	+1.38	.473	(26/55)	+1.50	.227	(10/44)	-0.35
Mar.-Apr.	.424	(25/59)	+0.78	.482	(27/56)	+1.65	.275	(11/40)	+0.37
Apr.-May	.519	(27/52)	+2.14	.410	(25/61)	+0.56	.167	(7/42)	-1.24
May-Jun.	.470	(31/66)	+1.59	.517	(31/60)	+2.27	.345	(10/29)	+1.18
Jun.-Jul.	.500	(29/58)	+1.97	.596	(34/57)	+3.45	.175	(7/40)	- 1.10
Jul.-Aug.	.559	(33/59)	+2.92	.565	(35/62)	+3.09	.324	(11/34)	+1.00
Aug.-Sept	.632	(36/57)	+4.01	.569	(33/58)	+3.05	.250	(10/40)	–
Sept.-Oct.	.541	(33/61)	+2.68	.526	(30/57)	+2.35	.297	(11/37)	+0.66
Oct.-Nov.	.531	(34/64)	+2.58	.448	(26/58)	+1.15	.303	(10/33)	+0.70
Nov.-Dec.	.419	(26/62)	+0.72	.518	(29/56)	+2.21	.297	(11/37)	+0.66
Dec.-Jan.	.404	(23/57)	+0.45	.500	(29/58)	+1.97	.300	(12/40)	+0.73

Incidence of Two-Month Persistence

Observed warm and cold regimes incidence exceeded expected incidence for all sequences, with observed near normal regime incidence exceeding expected for eight sequences. Warm and cold regimes were considerably more frequent relative to expected than near normal regimes, appearing to be most numerous during the summer and early autumn (roughly June-July to September-October); near normal regimes showed no apparent seasonal disposition. Individually (Table 3), maximum warm persistence (59.6 percent) was for July-August, minimum (41.0 percent) for April-May; maximum cold persistence (63.2 percent) was for August-September, minimum (40.4 percent) for December-January. Near normal persistence was most frequent for May-June (34.5 percent), least frequent for April-May (16.7 percent). The particularly high figure for August-September cold persistence indicated 155-year empirical odds of nearly 2 to 1 that a "cold" August would be followed by a "cold" September.

Utilizing the t-test for differences between a universe and sample proportion, three sequences' incidence percentages for cold persistence (July-August, August-September, and September-October), three for warm persistence (June-July, July-August, and August-September) but none for near normal persistence were statistically significant at the .005 level (critical value = 2.66). The weak near normal persistence is better exemplified by the fact that none of the sequences' t-values were even significant at the .10 level (critical value = 1.30).

The causes of this statistically significant warm and cold persistence probably relate to positional influences of the Azores-Bermuda and North Pacific semi-permanent high pressure systems, the prime air mass regulators for North America in the summer and early fall. These huge systems change position only very slowly, and any abnormal displacements usually result in extended periods of anomalous temperatures for affected regions. The weak near normal regime incidence is more puzzling, perhaps it indicates that near normal regimes are mere interludes or transitions between longer period above or below normal flucuations than self-perpetuating "spells" in themselves.

Same-Sequence Discrepancies

As the theoretical frequencies of warm and cold regimes were equivalent, of some interest also were intra-sequence discrepancies in actual warm and cold regime incidence. The largest intra-sequence predominance of cold persistence over warm persistence was for April-May, with cold regime incidence (51.9 percent) exceeding warm regime incidence (41.0 percent) by 26.6 percent. Conversely, the highest intra-sequence predominance of warm persistence over cold persistence was for November-December, with incidence of the former (51.8 percent) exceeding the latter (41.9 percent) by 23.6 percent. Considering the periods of the year that these sequences encompass, the differences may reflect tendencies for seasonal lags (cold lags in the instance of April-May, warm lags in the instance of November-December). Statistically (using the t-test for differences between two sample proportions), the discrepancies were significant at the .30 level ($t = 1.16$ for April-May: $t = 1.08$ for November-December).

December-January. Near normal persistence was most frequent for May-June (34.5 percent), least frequent for April-May (16.7 percent). The particularly high figure for August-September cold persistence indicated 155-year empirical odds of nearly 2 to 1 that a "cold" August would be followed by a "cold" September.

Utilizing the t-test for differences between a universe and sample proportion, three sequences' incidence percentages for cold persistence (July-August, August-September, and September-October), three for warm persistence (June-July, July-August, and August-September) but none for near normal persistence were statistically significant at the .01 level (critical value = 2.66). The weak near normal persistence is better exemplified by the fact that none of the sequences' t-values were even significant at the .20 level (critical value = 1.30).

The causes of this statistically significant warm and cold persistence probably relate to positional influences of the Azores-Bermuda and North Pacific semi-permanent high

Table 2. Classification of Minneapolis-St. Paul Monthly Mean Temperatures, January 1820 to January 1975 (Key: MB = Much Below; B = Below Normal; NN = Near Normal; A = Above Normal; MA = Much Above Normal)

Year	Month: Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1820	MB	NN	B	A	B	NN	MB	MB	B	B	B	MB
1821	B	B	B	MB	B	MA	MB	A	B	B	B	MB
1822	B	NN	A	B	NN	NN	NN	NN	B	MB	B	MB
1823	NN	MB	B	NN	B	A	NN	B	MB	B	B	B
1824	A	B	MB	MB	B	MB	B	B	B	MB	B	A
1825	NN	MA	A	MA	NN	NN	A	A	A	B	NN	B
1826	NN	B	NN	MB	MA	NN	B	MB	MB	NN	A	NN
1827	A	A	NN	B	NN	NN	B	NN	NN	NN	NN	B
1828	B	B	NN	B	B	A	NN	A	B	NN	A	A
1829	A	MB	NN	NN	MA	A	B	NN	B	A	MB	A
1830	NN	A	A	A	B	B	MA	NN	B	MA	MA	B
1831	B	B	NN	B	NN	NN	B	NN	MB	B	B	MB
1832	A	MB	MA	MA	MB	NN	NN	MB	B	A	NN	MA
1833	A	A	A	A	NN	MB	NN	NN	NN	MB	A	MA
1834	MB	MA	A	MA	NN	MB	A	A	B	B	MA	NN
1835	MA	MB	A	B	A	B	MB	MB	MB	B	MB	NN
1836	NN	NN	MB	B	MA	B	NN	MB	B	MB	NN	B
1837	A	A	B	MB	B	B	B	B	B	B	MA	NN
1838	B	MB	A	MB	MB	A	NN	A	NN	MB	MB	MB
1839	A	A	NN	MA	B	MB	NN	A	MB	A	B	NN
1840	NN	A	A	NN	MA	A	B	MB	B	MB	B	NN
1841	B	NN	A	MB	A	A	NN	NN	B	B	B	NN
1842	NN	NN	MA	A	MB	MB	MB	B	B	NN	MB	NN
1843	MA	MB	MB	B	MB	MB	B	B	B	MB	MB	A
1844	B	A	A	MA	B	MB	B	MB	MB	MB	B	NN
1845	A	MA	A	A	A	NN	A	NN	NN	B	B	B
1846	MA	A	MA	NN	MA	B	A	MA	MA	B	MA	A
1847	B	A	B	NN	MB	B	NN	B	B	NN	NN	NN
1848	A	A	NN	NN	A	NN	MB	B	MB	NN	MB	MB
1849	MB	B	NN	MB	B	B	B	MB	NN	B	MA	MB
1850	NN	NN	B	MB	B	NN	A	A	A	A	A	B
1851	A	A	MA	MA	A	A	A	B	MA	A	NN	B
1852	NN	A	NN	B	NN	A	A	A	MB	A	MB	B
1853	NN	MB	B	NN	B	B	MB	NN	NN	B	B	NN
1854	MB	NN	NN	A	NN	NN	A	A	A	A	NN	A
1855	NN	MB	B	A	A	B	NN	B	NN	B	NN	MB
1856	MB	B	MB	A	NN	A	A	B	NN	A	B	MB
1857	MB	B	B	MB	B	B	A	NN	A	NN	MB	A
1858	MA	B	MA	B	B	A	NN	NN	NN	B	MB	B
1859	NN	NN	A	MB	NN	MB	B	MB	MB	MB	NN	MB
1860	NN	NN	A	B	NN	B	MB	MB	MB	B	B	B
1861	B	NN	B	NN	MB	B	MB	MB	B	B	B	A
1862	B	MB	B	MB	B	MB	B	MB	B	B	B	A
1863	MA	NN	B	A	NN	MB	MB	MB	MB	MB	B	NN
1864	NN	A	B	B	B	B	B	B	MB	MB	B	MB
1865	A	MA	B	B	NN	NN	MB	MB	MA	B	A	MB
1866	NN	MB	MB	B	B	MB	NN	MB	MB	NN	NN	NN
1867	B	NN	MB	MB	MB	B	MB	B	B	B	NN	B
1868	MB	B	A	MB	B	B	MA	MB	MB	B	NN	B
1869	A	A	MB	B	B	MB	MB	B	NN	MB	B	NN
1870	NN	NN	B	A	A	A	NN	MB	A	NN	A	NN
1871	A	A	A	A	A	MB	B	B	B	B	B	MB
1872	A	A	B	NN	B	NN	NN	NN	B	B	MB	MB
1873	B	B	B	B	B	MA	B	NN	MB	MB	MB	NN
1874	NN	B	B	MB	A	A	A	NN	NN	NN	B	NN
1875	MB	MB	MB	MB	NN	MB	NN	B	B	MB	MB	MA
1876	A	NN	B	NN	A	B	NN	NN	B	B	B	MB
1877	B	MA	B	NN	A	B	A	MA	A	NN	NN	MA
1878	MA	MA	MA	MA	B	NN	A	A	A	B	MA	NN
1879	A	B	A	A	A	NN	A	A	B	MA	NN	B
1880	MA	A	NN	NN	MA	A	A	NN	NN	B	MB	B
1881	B	NN	A	NN	MA	A	A	MA	NN	NN	NN	MA
1882	A	MA	A	A	B	NN	MB	A	A	A	A	B
1883	MB	B	B	NN	MB	NN	NN	B	MB	B	NN	NN
1884	B	B	NN	A	A	A	B	NN	A	A	NN	B
1885	MB	B	NN	A	NN	A	A	B	NN	B	A	A
1886	MB	NN	NN	A	A	NN	A	A	NN	MA	B	MB
1887	MB	B	NN	NN	MA	A	A	B	B	MB	NN	NN
1888	MB	B	MB	B	MB	NN	NN	B	B	B	A	A
1889	MA	B	MA	A	B	B	B	NN	NN	B	B	MA
1890	NN	A	B	A	MB	A	NN	MB	B	B	A	A
1891	MA	B	B	A	A	NN	MB	B	MA	A	B	MA
1892	NN	A	NN	B	MB	B	NN	NN	A	MA	B	NN
1893	MB	B	B	B	B	MA	A	NN	A	A	NN	B
1894	NN	NN	MA	A	A	MA	MA	A	A	A	B	MA
1895	B	B	NN	MA	A	NN	B	NN	MA	B	NN	A
1896	A	A	B	A	MA	A	NN	A	B	B	MB	A
1897	NN	A	B	NN	NN	B	A	B	MA	MA	B	B
1898	MA	A	A	NN	NN	A	A	NN	A	B	B	B
1899	NN	MB	MB	A	NN	NN	A	A	NN	A	MA	A
1900	MA	MB	B	MA	MA	A	B	MA	A	MA	B	A
1901	A	B	NN	A	A	A	MA	A	NN	A	NN	B
1902	A	A	MA	NN	A	B	NN	B	B	NN	A	B
1903	A	NN	A	NN	A	B	B	MB	B	A	B	B
1904	B	MB	NN	B	NN	B	MB	B	NN	NN	MA	NN
1905	B	B	A	NN	B	B	B	A	A	B	A	A
1906	MA	NN	B	MA	B	NN	B	A	MA	NN	A	A
1907	B	NN	A	MB	MB	B	B	NN	B	NN	A	A
1908	A	A	NN	A	NN	B	NN	NN	MA	NN	A	A
1909	A	NN	NN	MB	B	NN	NN	MA	NN	B	MA	B
1910	A	B	MA	MA	B	MA	A	NN	A	MA	B	NN
1911	NN	A	A	NN	MA	MA	B	B	NN	B	MB	A
1912	MB	B	B	A	A	B	B	B	NN	A	MA	A
1913	NN	B	B	A	B	A	B	A	A	B	MA	MA
1914	MA	MB	NN	NN	A	NN	A	NN	A	MA	A	B
1915	NN	MA	NN	MA	MB	MB	MB	MB	NN	A	A	A
1916	B	B	B	NN	NN	MB	MA	A	NN	NN	A	B
1917	B	MB	NN	B	B	MB	NN	B	NN	MB	MA	MB
1918	MB	NN	MA	NN	A	NN	B	A	MB	A	MA	MA
1919	MA	NN	NN	NN	NN	A	A	NN	MA	B	MB	B
1920	B	NN	A	MB	A	A	B	NN	MA	MA	NN	A
1921	MA	MA	A	MA	A	MA	MA	NN	A	A	B	A
1922	NN	B	A	NN	MA	A	B	MA	MA	MA	MA	NN
1923	A	B	MB	NN	A	MA	MA	B	A	NN	MA	MA
1924	B	A	NN	NN	MB	B	B	B	B	MA	NN	MB
1925	NN	A	A	MA	B	NN	B	A	MA	MB	NN	NN
1926	A	MA	B	NN	MA	B	NN	NN	B	NN	B	B
1927	NN	A	A	NN	B	B	B	B	A	A	B	MB
1928	A	A	A	MB	A	MB	NN	NN	B	A	A	MA
1929	MB	B	A	A	B	B	A	A	NN	A	B	NN
1930	B	MA	A	A	NN	A	A	MA	A	NN	A	A
1931	MA	MA	A	A	B	MA	MA	A	MA	MA	MA	MA
1932	A	A	B	A	A	MA	A	A	A	B	NN	NN
1933	MA	NN	NN	NN	A	MA	MA	A	MA	NN	NN	NN
1934	MA	A	NN	NN	MA	MA	MA	NN	B	MA	MA	B
1935	NN	MA	A	NN	B	B	MA	A	A	NN	B	NN
1936	MB	MB	NN	MB	MA	NN	MA	MA	MA	B	B	A
1937	B	B	NN	NN	A	NN	MA	MA	A	B	NN	NN
1938	NN	A	MA	NN	NN	NN	A	MA	A	MA	NN	A
1939	A	B	NN	B	MA	A	A	A	A	NN	MA	MA
1940	B	A	B	NN	B	NN	MA	NN	MA	MA	B	A
1941	A	NN	NN	MA	MA	A	A	A	A	A	A	MA
1942	MA	A	MA	MA	B	NN	NN	NN	B	A	A	B
1943	B	NN	B	NN	B	A	A	A	B	NN	B	A
1944	MA	A	B	B	MA	A	NN	A	A	A	MA	NN
1945	NN	NN	MA	NN	MB	MB	B	A	NN	NN	NN	B
1946	A	NN	MA	MA	B	NN	A	NN	NN	A	NN	A
1947	MA	NN	NN	B	B	B	NN	MA	A	MA	MB	NN
1948	B	NN	NN	A	NN	NN	A	A	MA	A	A	A
1949	NN	B	NN	A	MA	MA	MA	MA	B	A	MA	A
1950	B	NN	B	MB	B	NN	B	B	A	MA	B	B
1951	B	NN	MB	B	MA	B	NN	B	B	NN	MB	NN
1952	NN	MA	B	MA	A	A	A	NN	A	B	A	A
1953	A	NN	A	B	A	MA	NN	MA	A	MA	MA	A
1954	NN	MA	NN	A	B	MA	A	NN	NN	NN	MA	A
1955	NN	NN	B	MA	MA	A	MA	MA	A	A	MB	B
1956	NN	NN	B	B	NN	MA	B	A	B	MA	A	A
1957	B	A	NN	A	NN	NN	MA	A	NN	NN	NN	MA
1958	MA	NN	A	A	A	MB	B	A	A	A	A	B
1959	NN	NN	A	A	A	MA	A	MA	A	B	MB	MA
1960	A	NN	MB	NN	NN	B	NN	A	A	NN	NN	NN
1961	NN	A	A	MB	B	A	B	A	NN	A	A	B
1962	B	B	B	B	A	NN	MB	B	B	A	A	NN
1963	MB	B	A	A	B	A	A	NN	A	MA	MA	MB
1964	MA	MA	B	A	A	A	MA	B	NN	NN	A	B
1965	B	B	MB	B	A	NN	B	B	MB	A	NN	MA
1966	MB	NN	MA	B	B	A	MA	B	NN	NN	B	NN
1967	A	B	NN	NN	MB	NN	B	B	NN	B	NN	A
1968	NN	NN	MA	A	B	NN	B	A	NN	A	A	NN
1969	B	A	B	A	A	MB	A	MA	A	B	A	A
1970	B	NN	B	NN	NN	MA	A	A	NN	NN	NN	NN
1971	B	NN	NN	A	B	MA	B	NN	A	A	NN	NN
1972	B	B	B	B	A	B	B	NN	B	B	NN	B
1973	A	A	MA	NN	B	A	A	MA	NN	MA	A	NN
1974	NN	NN	NN	A	B	B	MA	B	MB	A	A	A
1975	A											

pressure systems, the prime air mass regulators for North America in the summer and early fall. These huge systems change position only very slowly, and any abnormal displacements usually result in extended periods of anomalous temperatures for affected regions. The weak near normal regime incidence is more puzzling, perhaps it indicates that near normal regimes are more interludes or transitions between longer period above or below normal fluctuations than self-perpetuating "spells" in themselves.

Intra-sequence discrepancies of regime

As the theoretical frequencies of warm and cold regimes were equivalent, of some interest also were intra-sequence discrepancies in actual warm and cold regime incidence. The largest intra-sequence predominance of cold persistence over warm persistence was for April-May, with cold regime incidence (51.9 percent) exceeding warm regime incidence (41.0 percent) by 26.6 percent. Conversely, the highest intra-sequence predominance of warm persistence over cold persistence was for November-December, with incidence of the former (51.8 percent) exceeding the latter (41.9 percent) by 23.6 percent. Considering the periods of the year that these sequences emcompass, the differences may reflect tendencies for seasonal lags (cold lags in the instance of April-May, warm lags in the instance of November-December). Statistically (using the t-test for differences between two sample proportions), the discrepancies were significant at the .30 level ($t = 1.16$ for April-May; $t = 1.08$ for November-December).

Incidence of Two-Month Shifts

Observed incidence of both types was less than expected for every sequence, this primarily a consequence of the sequences' tendencies for warm and cold persistence. Greatest incidence of each type was shown for roughly the spring and autumn, reflecting tendencies for uneven progression of warming or cooling during these transitional periods.

Individually, maximum incidence for both cold and warm shifts was for April-May (cold shift incidence, 31.1 percent; warm shift incidence, 28.7 percent), minimum incidence for each shown for August-September (cold shift incidence, 16.3 percent; warm incidence, 15.5 percent).

Discrepancies of Shift Incidence

Greatest intra-sequence predominance of cold shifts over warm shifts was for January-February, with the former's incidence (27.8 percent) exceeding the latter's (19.6 percent) by 40.8 percent. This discrepancy probably reflected the predominance of polar influences on Twin Cities' temperatures during January and February. Downward "lapses" in classification, owing to the susceptibility of the Twin Cities' to polar outbreaks, were relatively common compared to upward "recoveries", whose somewhat weaker incidence reflected the greater difficulty air masses from warmer regions have in penetrating the area.

Greatest excess of warm shifts over cold shifts, in contrast, was for December-January, with the former's incidence (27.8 percent) being 9.0 percent higher than the latter's (25.5 percent); this disparity was not likely pronounced enough to suggest of any natural inherencies.

Statistically, the January-February discrepancy was significant at the .25 level ($t = 1.32$), the December-January discrepancy at the .75 level ($t = 0.36$).

Persistence Indices

Table 5 shows the sequences' persistence indices (total regimes minus total shifts) for the 1820-1974 period, expected index being -9.7 (53.3 regimes, 63.0 shifts).

Observed indices exceeded the expected index for every sequence, indicative of at least some positive temperature association for each. The maximum index, +48, was for August-September (79 regimes, 31 shifts) with the minimum, 0, for April-May (59 regimes, 59 shifts); August-September's index exceeded April-May's by 48/310 or 15.5 percent (see Table 5 below).

From the indices, a crude ranking of the sequences' temperature relationships in descending order is possible: August-September (+48), July-August (+42), September-October (+29), June-July (+28), January-February (+26), May-June (+24), October-November (+19), February-March and March-April each (+15), November-December (+14), December-January (+12), and April-May (0). It is interesting to note that the persistence indices for the non-adjacent sequences, June-August (+31), and July-September (+29) were also relatively high, further indicative of the high temperature persistence that characterizes summer.

Table 5. Persistence Indices, by sequence, 1820-1974 (Total Regimes minus Total Shifts)

Sequence	Total Regimes	Total Shifts	Index
January-February	72	46	+26
February-March	62	47	+15
March-April	63	48	+15
April-May	59	59	0
May-June	72	48	+24
June-July	70	42	+28
July-August	79	37	+42
August-September	79	31	+48
September-October	74	45	+29
October-November	70	51	+19
November-December	66	52	+14
December-January	64	52	+12

ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation to Dr. William Girard, Dr. Donald Roscoe, Mr. Max Morgan, and the late Dr. LeRoy Olson, all of Mankato State University, for their encouragement and assistance in the preparation of this paper.

REFERENCES

DICKSON, R. 1967. The Climatological Relationship Between Temperatures of Successive Months. Jnl. Applied Meteorology, 6:1.

NAMAIS, J. 1952. The Annual Course of Month-to-Month Persistence in Climatic Anomalies. Bull. American Meteorological Society, 33:7,

KIMBLE, G. 1961. Our American Weather. Bloomington, Indiana University Press.

RICHMOND, S. 1964. Statistical Analysis. New York, Ronald Press.

PETERSON, the Rev. A.B. - Diaries, St. Paul. 1859-1876. (Minnesota Historical Society.)

St. Paul Daily Pioneer, May through December, 1858.

U.S. Department of Commerce. 1930. Climatic Summary of the United States - Section 46 - Southeastern Minnesota. Washington, U.S. Government Printing Office.

U.S. Department of Commerce. Local Climatological Data - Minneapolis-St. Paul, Minnesota, 1926 through 1974.

Weather diaries kept by the Rev. A. B. Peterson, St. Paul (1859-1872).